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SUMMARIES OF PRE-CAMBRIAN LITERATURE OF NORTH AMERICA

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INTRODUCTORY

In 1915, summaries of pre-Cambrian literature from 1909 to 1915 were published in the *Journal of Geology*. The summaries published herewith bring this review nearly down to date. For 1919, attention has been given only to those publications which are likely to contain important papers on the pre-Cambrian. Emphasis in these summaries is placed on stratigraphic facts and problems.

I. LAKE SUPERIOR REGION AND ISOLATED PRE-CAMBRIAN AREAS OF THE MISSISSIPPI VALLEY

In the Lake Superior region notable contributions to the stratigraphy of the pre-Cambrian have been made by Wolff, Grout and Broderick, Hotchkiss, and Allen and Barrett. The tendency has been to subdivide the iron formations of the leading districts into several units and to connect the occurrence of major ore deposits with certain of these units. In the main productive portion of the Mesabi district, Wolff from his extended experience in drilling and mining has recognized four divisions of the Biwabik iron formation. Grout and Broderick have recognized similar units in the eastern, less-productive portion of the formation. Hotchkiss has found an unconformity in the Ironwood iron formation of the Gogebic district and has recognized two units in the upper division and three in the lower. He has also found an unconformity between the iron formation and the overlying Tyler slates. The recognition of these new unconformities, Hotchkiss believes, does not call for a revision of correlation. Allen has discovered an unconformity cutting the Upper Huronian

formations of Van Hise and Leith in the eastern part of the Gogebic district. Between the Keweenawan and this unconformity, Allen finds a series of clastic sediments which are neither Keweenawan nor Upper Huronian. Allen decides that the Upper Huronian of Van Hise and Leith is to be correlated with the Middle Huronian of the Marquette district. On much less convincing evidence than in the Gogebic district he also concludes that a Middle Huronian is found in the Menominee district. Following these studies, a revised correlation of the Lake Superior region is offered by Allen in which all the important iron formations of the region are designated as Middle Huronian.

Allen has made important studies of the region between the Penoque and Iron River districts, but owing to the drift cover of the area he has not obtained the facts for a satisfactory correlation of the Iron River with the Penoque and Marquette districts. He has also studied the Gwinn district and the eastern extension of the Menominee district.

R. C. Allen¹ believes that the pre-Cambrian rocks of the Gwinn district located about sixteen miles south of Marquette, Michigan, comprise two unconformable series which he correlates with the Upper and Middle Huronian respectively. The succession according to Allen is shown on page 560.

The graywacke and conglomerate near the middle of the sedimentary succession constitutes the evidence on which Allen bases his conclusion for unconformity in the Huronian system. The conglomerate contains fragments which resemble the underlying sediments including iron ore. The two unconformable series appear to be structurally concordant however.

His correlation of the lower series with the Middle Huronian is based on the fact that the Lower Huronian is not known to contain iron formation of the type in the Gwinn district.

Allen and Barrett² believe that the acid mica schists of Wolf Lake are the metamorphosed equivalent of the Paint slates of

¹ R. C. Allen, "Correlation and Structure of the Pre-Cambrian Rocks of the Gwinn Iron Bearing District of Michigan," *Jour. Geol.*, Vol. XXII, No. 6 (1914); also in *Mich. Geol. Surv. Pub.* 18 (1915), Geol. Ser. 15, pp. 161-64.

² R. C. Allen and L. P. Barrett, "The Paint Slate and the Wolf Lake Granite, Gneiss and Schist," *Mich. Geol. Surv. Pub.* 18 (1915), Geol. Ser. 15, pp. 131-39.

the Iron River and Crystal Falls districts. The granite intrusive into them, they believe, is of the same age as their Presque Isle granite of the Gogebic district. Wolf lake is situated between the Iron River and Gogebic districts.

Quaternary—Pleistocene glacial deposits

Ordovician and Cambrian—limestone and sandstone

Algonkian—Keweenaw, probably represented by certain basic dikes which cut all formations

Upper Huronian Princeton series	{ Slate, ferruginous slate, chert and quartzite, quartz- ite Conglomerate graywacke	} Equivalent of Michi- gamme slate
Unconformity Middle Huronian Gwinn series	{ Gray slate Black slate Iron formation Gray slate Black slate	} Equivalent of Negaunee iron formation and Siamon slate
Unconformity	{ Arkose Conglomerate	} Equivalent of Ajibik slate
Archean system		
Laurentian—Granite and greenstone, mainly granite		
Keewatin		

Allen and Barrett¹ find that the pre-Cambrian rocks at the Little Lake Hills about seven miles east of the Gwinn district of Michigan consist from the base upward of conglomerate, arkose, and quartzite separated by an unconformity from a conglomerate quartz slate and quartzite respectively. The strata appear to be concordant, but the conglomerate near the middle of the column is clearly basal. The lower series is correlated with the Middle Huronian Gwinn series of the Gwinn district; the upper series with the Upper Huronian-Princeton series of the aforementioned district. The absence of iron formation in the Little Lake Hills, Middle Huronian is thought by the writers to indicate the depth of erosion of the Gwinn series before the Princeton series were laid down.

¹ R. C. Allen and L. P. Barrett, "Evidence of the Middle-Upper Huronian Unconformity in the Quartzite Hills at Little Lake, Michigan," *Mich. Geol. Surv. Pub.* 18 (1915), Geol. Ser. 15, pp. 153-59.

Allen¹ finds a series of magnetic belts in a region covered by Paleozoic rocks and glacial drift extending east of Waucedah on the Menominee range to Escanaba, a distance of about twenty-eight miles. From Waucedah, the buried eastward extensions of two productive iron formations have been traced for six miles by magnetic survey. The detached magnetic belts east of this limit may or may not be equivalent to the iron ranges at Waucedah. They undoubtedly represent belts of folded sedimentary rocks which may include iron formation.

Allen and Barrett² describe the Conover district of northern Michigan, about forty-five miles southeast of the Gogebic range, as a drift-covered area showing several magnetic belts. Drilling has shown that the underlying rocks are slates intruded by granites. The authors believe that the slates are the equivalent of the iron-bearing slates of the Iron River district.

Allen and Barrett³ state that the existence of the Manitowish range is indicated by a series of strong, parallel linear magnetic belts about twenty-five miles southeast and parallel to the Gogebic range. Drilling has shown that the underlying drift-covered rocks are mica schists intruded by granites.

Allen and Barrett⁴ report that the Vieux Desert district of Wisconsin and Michigan lying about forty miles southeast of the Gogebic range is a deeply drift-covered area showing several faint magnetic belts. As shown by drilling, the underlying rocks are acid gneisses and schists.

Allen and Barrett⁵ correlate the strongly magnetic iron formation of the Marenisco range with the Ironwood formation of the

¹ R. C. Allen, "Relative to an Extension of the Menominee Iron Range Eastward from Waucedah to Escanaba, Michigan," *Econ. Geol.*, Vol. IX, No. 3 (1914), pp. 236-38, 1 map; also in *Mich. Geol. Surv. Pub. 18* (1915), Geol. Ser. 15.

² R. C. Allen and L. P. Barrett, "Geology of the Conover District," *Mich. Geol. Surv. Pub. 18* (1915), Geol. Ser. 15, pp. 123-29.

³ R. C. Allen and L. P. Barrett, "Geology of the Manitowish Range," *Mich. Geol. Surv. Pub. 18* (1915), Geol. Ser. 15, pp. 111-17.

⁴ R. C. Allen and L. P. Barrett, "Geology of the Vieux Desert District," *Mich. Geol. Surv. Pub. 18* (1915), Geol. Ser. 15, pp. 119-21.

⁵ R. C. Allen and L. P. Barrett, "Geology of the Marenisco Range," *Mich. Geol. Surv. Pub. 18* (1915), Geol. Ser. 15, pp. 65-86.

Gogebic district. Both are classified by them as Middle Huronian. The succession in the Marenisco range, they state, is as follows:

Keweenawan		Diabase
	Igneous contact	
Huronian	Middle Huronian (Animikie)	{ Intrusive granite { Intrusive greenstone { Slate { Extrusive lavas { Iron formation { Quartzite and graywacke
	Unconformity	
Archean	{ Northern Area—granite and greenstone { Southern Area—mica schist, green schist, and amphibolite { (may be Huronian)	

The Marenisco range lies three to twelve miles south of and is parallel to the Gogebic range.

Allen and Barrett¹ describe the Turtle iron range about eighteen miles southeast of and parallel to the Gogebic range of northern Wisconsin and Michigan. The succession of the range as stated by the authors is as follows:

ALGONKIAN:

Keweenawan	{ Intrusive diabase { Granite and greenstone	
	{ Middle Huronian { (Animikie)	{ Granite { Effusive { Agglomeratic and ellipsoidal { Greenstone { Black slate and graphitic schist { Iron formation { Quartzite and mica schist
Huronian	{ Unconformity ? { Lower Huronian	{ Mica schist (may be Middle Huronian) { Dolomite and dolomitic quartzite { Quartzite

Unconformity

ARCHEAN:

Keewatin	{ Mica schist and { green schist
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¹ R. C. Allen and L. P. Barrett, "Geology of the Turtle Range," *Mich. Geol. Surv. Pub.* 18 (1915), Geol. Ser. 15, pp. 86-109.

Allen and Barrett¹ find that a group of dominantly clastic sediments overlies with marked unconformity the Upper Huronian of Van Hise and Leith in the Gogebic district. They also find that a granite intrudes the Upper Huronian. Their threefold division of the rocks between the Keweenawan and the Archean of the Gogebic, they claim, identifies this succession with the three Huronian divisions of the Marquette district. They designate as Middle Huronian, the Upper Huronian of Van Hise and Leith in the Gogebic district and extend this change to the correlation by these authors to every other district of the Lake Superior region, outside of the Marquette district. The revised correlation table which Allen and Barrett offer places every important Lake Superior iron formation excepting that of the Vermilion district in the Middle Huronian.

In 1919, Allen² extended to the Menominee district the threefold classification of the Huronian which he had found applicable to the Gogebic district of northern Michigan. His revised correlation of the Huronian of the Menominee district is shown on page 564.

In previous correlations of the Menominee, notably that of Bayley in Monograph 46 of the U.S. Geological Survey, the Middle and Upper Huronian of Allen were regarded as a conformable succession designated Upper Huronian. Van Hise and Leith, in 1911, recognized a Middle Huronian quartzite, but later Leith is said to have given up this revision. Allen bases his separation of the Upper Huronian of Bayley on the fact that some drill holes have shown what is interpreted as a basal conglomerate between the Hanbury slate and the Curry iron formation. Many drill holes do not show this conglomerate. He also appeals to the fact that the Randville dolomite in different places is covered by various formations ranging from the Traders iron formation to the Hanbury slates. Bayley had accepted one of the alternative explanations for this fact, viz., that the formations overlying the Randville were all conformably deposited on a very uneven surface of the

¹ R. C. Allen and L. P. Barrett, "Contributions to Pre-Cambrian Geology," *Mich. Geol. Surv. Pub.* 18 (1915), Geol. Ser. 15, pp. 13-164, 12 pls., 11 figs., maps.

² R. C. Allen, "Correlation of Formations of Huronian Group in Michigan," *Am. Inst. Min. and Met. Eng.* (1919), No. 153, pp. 2579-94.

Randville. Allen emphasizes this relation of the Hanbury slate as evidence of unconformity with the Curry iron-formation group. No proof of angular discordance between the Hanbury slates and the Curry iron formation seems to have been found by Allen. His recognition of the Loretto slate is based on the fact that on a certain

Period	Epoch	Stage	Formation
Epi-Huronian	Revolution	Emergent interval	Granite
Huronian	Upper Huronian	Quinnebec	Eruptive contact, basic extrusives, sills and dikes
		Hanbury	Great slate series with beds of conglomerate, quartzite, graywacke, ferruginous chert, and impure limestone. Thickness?
	Emergent	interval	
	Middle Huronian	Loretto	Slate 400 feet
		Curry	Iron formation 100 to 200 feet
	Lower Huronian	Brier	Ferruginous, siliceous banded slate 300 to 400 feet
		Traders	Conglomerate, quartzite, and iron formation 150 feet
	Emergent	interval	
	Lower Huronian	Randville	Dolomite, cherty dolomite, and talcose facies 1,000 to 1,500 feet. Conglomerate, arkose, graywacke, and quartzite 1,200 feet
	Great Archeozoic	interval	

forty-acre lot, a few drill holes passed through what he assumes to be the basal Hanbury conglomerate and then through a slate before striking the Curry iron formation. It appears that Allen's revision is based solely on a very local occurrence of a fragmental rock above the Curry iron formation.

Broderick¹ presents a detailed classification of the beds of the Biwabik iron formation in the eastern part of the Mesabi range. He retains Wolff's general classification into Upper slaty

¹ T. M. Broderick, "Detail Stratigraphy of the Biwabik Iron Bearing Formation, East Mesabi District, Minnesota," *Econ. Geol.*, Vol. XIV (1919), pp. 441-51.

beds, Upper cherty beds, Lower slaty beds, and Lower cherty beds.

Broderick¹ interprets certain negative magnetic lines of the Duluth gabbro as due to a certain angle of inclination of the magnetic formations with the horizontal.

According to Cayeux² traces of crinoids are found in the iron formations of the Gogebic, Mesabi and Menominee ranges. They consist of circular, quadrilateral, and hemispherical bodies larger than the oölites and of polygonal cells whose walls are composed of iron. The cells occur with and without alignment.

Grout³ finds that siliceous pegmatites formed on all sides of the basic Duluth gabbro, but that distinct dikes occur only outside the contact. He infers that the two magmas separated in the liquid state.

Grout⁴ presents interesting petrographic descriptions of the Biwabik iron formation of the eastern part of the Mesabi district. He concludes that originally the iron formation was a shallow water deposit formed mainly by organic processes.

Grout⁵ proposes the name lopolith for intrusions like the Duluth gabbro whose floors and roof sag downward toward the middle. Evidence is introduced for concluding that the main mass of this intrusion was along a plane of unconformity. Suggestions are made that the method of intrusion of the lopolith is different from that of a laccolith.

Grout believes, as indicated by his diagrams, that the dip of the pre-Cambrian beds around the western rim of Lake Superior is due to settling rather than compression. It would be interesting to find out whether the nature of the fracture and flow cleavage structures in these formations checks with this view.

¹ T. M. Broderick, "Some Features of Magnetic Surveys of the Magnetic Deposits of the Duluth Gabbro," *Econ. Geol.*, Vol. XIII (1918), pp. 35-49.

² L. Cayeux, "Existence de restes organique dans le roche ferrugineuses associées aux minéraux de fer huroniens des Etats-Unis," *Acad. Sci. Paris Compt. rend.*, Vol. 153, pp. 910-12.

³ F. F. Grout, "The Pegmatites of the Duluth Gabbro," *Econ. Geol.*, Vol. XIII (1918), pp. 185-97.

⁴ F. F. Grout, "The Nature and Origin of the Biwabik Iron Bearing Formation of the Mesabi Range, Minnesota," *Econ. Geol.*, Vol. XIV, (1919), pp. 452-64.

⁵ F. F. Grout, "Lopolith, an Igneous Form Exemplified by the Duluth Gabbro," *Am. Jour. of Science*, Vol. CXCVI (1918), pp. 516-22.

Grout¹ states that the Duluth gabbro lopolith shows differentiation into the gabbro and granite families and discusses the problem of the processes of differentiation.

Hore² presents descriptions of the most important copper lodes of Upper Michigan, and reviews the literature of the region. He concludes that the ores are replacement deposits formed by chloride solutions liberated with the formation of the traps in which they occur or with which they are associated; that they have not been modified except in very minor ways since they were formed; but that the rocks in which they are formed were farther tilted since the ores were formed.

Hotchkiss, Bean, and Wheelwright³ map a part of the pre-Cambrian area of Ashland, Bayfield, Washburn, Sawyer, Price, Oneida, Barron, Rusk, and Chippewa counties. The chief aim of the work is to show the distribution of iron-bearing formations. Since the area is nearly all drift-covered, magnetic surveys furnish most of the facts. The pre-Cambrian sediments are classed as Barron quartzite and undivided Huronian. Keweenawan traps and granites and gneisses probably of various ages are found in the area. The report has notable chapters on field methods used in work of this type and on the nature and interpretation of magnetic data.

Hotchkiss⁴ has made an important contribution to the study of the stratigraphy and structure of the Gogebic iron district of northern Wisconsin and Michigan. The influence of stratigraphy and structure on the formation of the ores is also discussed by him. Many new facts and relationships are presented. Although he recognizes several new unconformities in the succession, he does not believe that the facts now known warrant any fundamental

¹ F. F. Grout, "A Type of Igneous Differentiation," *Jour. Geol.*, Vol. XXVI (1918), pp. 626-58.

² R. E. Hore, "Michigan Copper Deposits," *Mich. Geol. Surv. Pub.* 19 (1915), pp. 19-161, 18 pls., 16 figs.

³ W. O. Hotchkiss, "Mineral Land Classification Showing Indications of Iron Formations," *Wis. Geol. Surv. Bull. No. 44* (1915), 378 pp., 8 pls., 39 figs. (incl. maps).

⁴ W. O. Hotchkiss, "Geology of the Gogebic Range and Its Relation to Mining Developments," *Eng. and Min. Jour.*, Vol. CVIII (1919), pp. 443-52, 501-7, 537-41, 577-85.

revision of the classification by Van Hise and Leith. The essentials of the stratigraphic classification by Hotchkiss follow:

Keweenaw sandstones and conglomerates overlain by basic flows

Unconformity

Tyler graywacke slate 0-2 miles thick	{	Graywacke slates Iron carbonate slates Pabst member-cherty and fragmental slate beds
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Unconformity

Upper Ironwood formation	{	Anvil wavy-bedded ferruginous chert member Pence even-bedded ferruginous slate member
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Slight unconformity

Lower Ironwood formation	{	Norrie wavy-bedded ferruginous chert member Yale member—interbedded ferruginous cherts and ferruginous slates Plymouth member—wavy-bedded ferruginous chert (most mines located on this member)
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Palms quartzite 400 feet to 800 feet

Unconformity

Bad River cherty dolomite with quartzite below in eastern part of district

Unconformity

Granite and green schist both of igneous origin

The unconformities within the Ironwood formation and between the Tyler slate and the Ironwood formation have not been described before. Their existence is inferred from basal conglomerates and evidences of erosion of the members underlying the unconformity.

Lane¹ finds that the strata on the east side of the Copper range were uplifted and the eastern sandstone deposited on them. The Trap range subsequently overrode the sandstones in places several hundred feet.

Leonard² states that pre-Cambrian granite struck in wells of the Red River valley is the only known pre-Cambrian rock of North Dakota.

¹ A. C. Lane, "Abstract," *Bull. Geol. Soc. of America*, Vol. XXIV (1913), p. 718.

² A. G. Leonard, "The Geology of North Dakota," *Jour. Geol.*, Vol. XXXVII (1919), pp. 1-27.

Leith¹ suggests that the unconformity at the base of the Cambrian was developed by a process of cut and fill, and that the common occurrence of late pre-Cambrian terrestrial sediments is more than a coincidence, but is related to the development of the basal Paleozoic unconformity.

Nebel² presents a petrographic study of certain basal portions of the Duluth gabbro and its contact effects.

Powers³ reports that drilling in the east-central portion of Kansas has shown the existence of pre-Cambrian granite of considerable relief occurring along a north-south line.

Wolff⁴ reports that the average thickness of the Mesabi iron formation is six hundred and twenty feet, and that it consists of four divisions which from the top down are as follows: Upper slaty horizon, Upper cherty horizon, Lower slaty horizon, and Lower cherty horizon. The ores occur chiefly in the two cherty horizons and in the Lower slates. Marked differences exist between the ores of the various horizons.

¹ C. K. Leith, "Relations of the Plane of Unconformity at the Base of the Cambrian to Terrestrial Deposition in Late Pre-Cambrian Time," *Congrès Géologique International*, XII. Session Canada, pp. 333-37.

² M. L. Nebel, "The Basal Phases of the Duluth Gabbro Near Gabamichigami Lake, Minnesota, and Its Contact Effects," *Econ. Geol.*, Vol. XIV (1919), pp. 367-402.

³ Sidney Powers, "Granite in Kansas," *Am. Jour. of Science* (4th ser.), Vol. XLIV (1917), pp. 146-50, 1 fig.

⁴ J. F. Wolff, "Recent Geologic Developments on the Mesabi Range, Minnesota," *Am. Inst. Min. Eng. Bull. No. 118* (1916), pp. 1763-87, 14 figs.

[To be continued]